NASA SBIR 2022 Phase I Solicitation

Z7.03 Entry and Descent System Technologies

Lead Center: LaRC

Participating Center(s): ARC

Scope Title

Entry and Descent System Technologies

Scope Description

NASA is advancing deployable aerodynamic decelerators to enhance and enable robotic and human space missions. Applications include Mars, Venus, and Titan as well as payload return to Earth from low Earth orbit. The benefit of deployable decelerators is that the entry vehicle structure and thermal protection system are not constrained by the launch vehicle shroud. Deployable decelerators have the flexibility to more efficiently use the available shroud volume and can be packed into a much smaller volume for Earth departure, addressing potential constraints for payloads sharing a launch vehicle. For Mars, this technology enables delivery of a very large (20 metric tons or more) usable payload, which may be needed to support human exploration. The technology also allows for reduced-cost access to space by enabling the recovery of launch vehicle assets. Development of efficient gas generator technology is needed for inflation of large inflatable decelerators. NASA is also seeking development of domestic capability for fabricating custom stretch-broken carbon and polymer blended yarns for traditional thermal protection systems for other planetary entry missions. This subtopic area solicits innovative technology solutions applicable to both deployable and traditional entry concepts. Specific technology development areas include (1) gas generators for hypersonic inflatable aerodynamic decelerators (HIAD) and (2) blended phenolic/carbon yarn for 3D woven ablative thermal protection systems.

1. Gas Generators for HIAD

Development of gas generator technologies used as inflation systems that result in improved mass efficiency and system complexity over current pressurized cold gas systems for inflatable structures is desired. Inflation gas technologies can include warm or hot gas generators, sublimating powder systems, or hybrid systems; however, the final delivery gas temperature must not exceed 200 Â°C. Lightweight, high-efficiency gas inflation technologies capable of delivering gas at 250 to 10,000 standard liters per minute (SLPM) are sought. This range spans a number of potential applications. Thus, a given response need not address the entire range. Additionally, the final delivery gas and its byproducts must not harm aeroshell materials such as the fluoropolymer liner of the inflatable structure. Minimal solid particulate is acceptable as a final byproduct. Water vapor as a final byproduct is also acceptable for lower flow (250 to 4,000 SLPM) and shorter duration missions, but it is undesirable for higher flow (8,000 to 10,000 SLPM) and longer duration missions. Chillers and/or filters can be included in a proposed solution, but they will be included in assessing overall system mass versus amount of gas generated. Gas delivery configurations that rely on active flow control devices are not desired. Long-term mission applications will have inflatable volumes in the range of 1,200 to 4,000 ft^3 with final inflation pressures in the range of 15 to 30 psid. Initial concepts will be demonstrated with small-scale volumes to achieve the desired inflation pressures and temperatures. Focus of Phase I development can be subscale manufacturing demonstrations that demonstrate proof of concept and lead to Phase II manufacturing scaleup for applications related to human-scale Mars entry, Earth return, launch vehicle asset recovery, or the emergent small-satellite community.

2. Blended Phenolic/Carbon Yarn for 3D Woven Ablative Thermal Protection Systems

Development of domestic capability for fabricating custom stretch-broken carbon and polymer blended yarns is desired. Specifically, NASA is interested in the ability to twist and ply stretch-broken fibers into a 4-ply blended yarn of varying carbon/phenolic/thermoset resin ratios (phenolic or other nonbrittle fibers preferred). Challenges include maintaining an intimate blend ratio to maintain consistent linear weight while also fabricating a high-quality yarn free from breaks and large yarn defects (e.g., slubs and flames in the resin phase), with uniformity in diameter such that yarns are capable of being processed into 3D woven preforms for advanced thermal protection systems. Phase I effort shall identify the ability to fabricate these custom yarns and establish the characterization processes and controls that will be necessary to eventually fine-tune the blended yarn properties. Final composition of interest to NASA would be a carbon/phenolic blended yarnâ€”any surrogate polymeric yarn should have similar stretch-breaking and blending performance such that any successful process shown with surrogate yarn is extensible to a carbon/phenolic blend with low risk. Notional Phase II effort would demonstrate blending of stretch-broken carbon/kynol fibers and detailed yarn testingâ€”char, strength, yield, etc.â€”to meet the following established NASA specifications:

- Carbon to phenolic ratio in the yarn by mass shall be 63 Â± 4% carbon to 37 Â± 4% phenolic
- Blended yield shall be 1,140 yd/lb +/- 10%.
- Yarn shall have a minimum strength of >13,000 cN and elongation of >1%.
- Yarn shall have a twist in the â€œSâ€ direction and shall be 115 +/- 15% T/m (twists per meter) (2.92 T/in.).
- Yarn shall be manufactured so as to reduce presence of surface features such as slubs or flames.

Expected TRL or TRL Range at completion of the Project

1 to 4

Primary Technology Taxonomy

Level 1

TX 09 Entry, Descent, and Landing

Level 2

TX 09.1 Aeroassist and Atmospheric Entry

Desired Deliverables of Phase I and Phase II

- Research
- Analysis
- Prototype
- Hardware
- Software

Desired Deliverables Description

Reports documenting analysis and development results, including description of any hardware or prototypes developed. Focus of Phase I development can be material coupons and/or subscale manufacturing demonstrations that demonstrate proof of concept and lead to Phase II scaleup and testing in relevant environments for applications related to Mars and other planetary entry, Earth return, launch asset recovery, or the emergent small-satellite community.

State of the Art and Critical Gaps

The current state of the art for deployable aerodynamic decelerators is limited due to novelty of this technology. Development of gas generator technologies that improve mass efficiency over current pressurized cold gas systems for inflatable structures is needed. Domestic capability for producing blended phenolic/carbon yarn for 3D woven thermal protection systems is nonexistent, and NASA is interested in developing this domestic capability for future missions.

Relevance / Science Traceability

NASA needs advanced deployable aerodynamic decelerators to enhance and enable robotic and human space missions. Applications include Mars, Venus, and Titan as well as payload return to Earth from low Earth orbit. NASA also needs domestic supply of blended phenolic/carbon yarn for 3D woven traditional thermal protection systems. HEOMD (Human Exploration and Operations Mission Directorate), STMD (Space Technology Mission Directorate), and SMD (Science Mission Directorate) can benefit from this technology for various exploration missions.

References

- Hughes, S. J., et al., â€œHypersonic Inflatable Aerodynamic Decelerator (HIAD) Technology Development Overview,â€ AIAA Paper 2011-2524.
- Bose, D. M, et al., â€œThe Hypersonic Inflatable Aerodynamic Decelerator (HIAD) Mission Applications Study,â€ AIAA Paper 2013-1389.
- Hollis, B. R., â€œBoundary-Layer Transition and Surface Heating Measurements on a Hypersonic Inflatable Aerodynamic Decelerator with Simulated Flexible TPS,â€ AIAA Paper 2017-3122.
- Olds, A. D., et al., â€œIRVE-3 Post-Flight Reconstruction,â€ AIAA Paper 2013-1390.
- Del Corso, J. A., et al., â€œAdvanced High-Temperature Flexible TPS for Inflatable Aerodynamic Decelerators,â€ AIAA Paper 2011-2510.
- Cassell, A., et al., â€œADEPT, A Mechanically Deployable Re-Entry Vehicle System, Enabling Interplanetary CubeSat and Small Satellite Missions,â€ SSC18-XII-08, 32nd Annual AIAA/USU Conference on Small Satellites.
- Cassell, A., et al., â€œADEPT Sounding Rocket One Flight Test Overview,â€ AIAA Paper 2019-2896.
- Ellerby, D., et al., â€œHeatshield for Extreme Entry Environment Technology (HEEET) Thermal Protection System (TPS),â€ Materials Science and Technology (MS&T) 2019, September 29-October 3, 2019, Portland, Oregon.